

(12) **UK Patent Application** (19) **GB** (11) **2 348 447** (13) **A**

(43) Date of A Publication **04.10.2000**

(21) Application No **9907017.9**

(22) Date of Filing **27.03.1999**

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(51) INT CL⁷
C09K 7/02 , E21B 33/14 43/26 43/27

(52) UK CL (Edition R)
E1F FGP FJT FPA FPD

(56) Documents Cited
GB 2294485 A

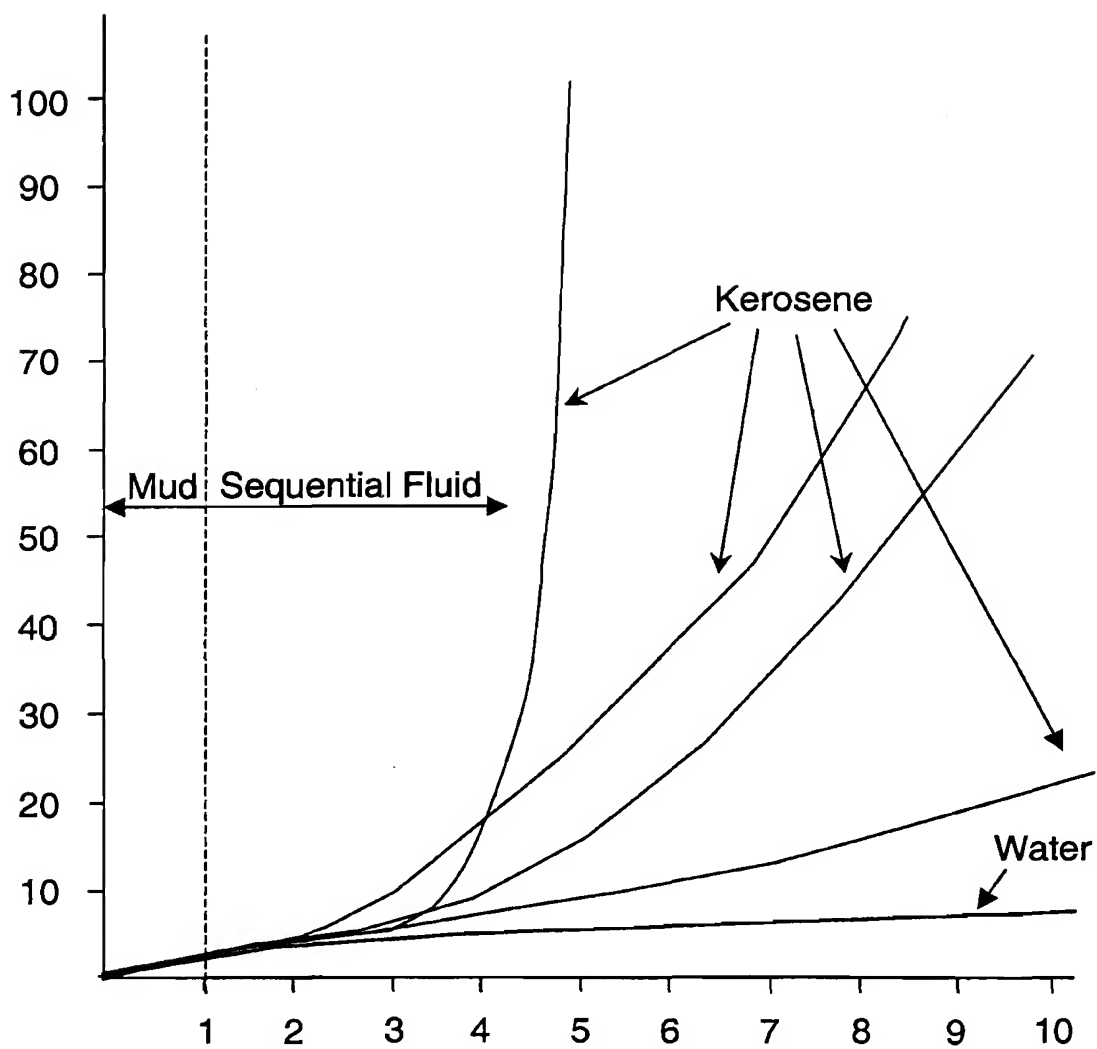
(58) Field of Search
UK CL (Edition Q) E1F FGP FJT FPA FPD
INT CL⁶ C09K , E21B
Online: WPI, EPODOC, PAJ

(54) Abstract Title
Wellbore service fluids

(57) An aqueous wellbore service fluid comprises a crystalline, particulate additive which is soluble in hydrocarbons and insoluble in an aqueous solution. The additive prevents fluid loss from a wellbore by accumulating at the face of a permeable formation after which it can be removed by letting hydrocarbons enter the wellbore from the formation thereby dissolving at least a part of the accumulated additive. Preferably the additive has a molecular weight of less than 1000 and a melting point over 80°C. Examples of the additive are 1S-endo-Borneol, camphor, iodine, beta carotene, lycopene, cholesterol, lanosterol and agnosterol.

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Additive for Wellbore Fluids

This invention relates to an additive for wellbore fluids. More specifically, it pertains to an additive for modifying the properties of a filtercake formed at the boundary between wellbore and formation.

BACKGROUND OF THE INVENTION

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For the production of hydrocarbon wells, boreholes are drilled into subterranean formations. Following standard procedures, a fluid is circulated during drilling from the surface through the interior of the drill string and the annulus between drill string and formation. The drill fluid also referred to as drilling mud is used to lubricate the drill bit. It also balances the formation pressure so as to prevent formation fluids to enter the borehole in an uncontrolled manner.

20 The industry distinguishes between largely three classes of drilling fluids: oil-based, water-based and so-called synthetic muds. Whereas oil-based muds are recognized for their superior qualities for most of the drilling operations themselves, they become increasingly undesirable due to their impact on the environment and stricter environmental legislation. Water-based muds are expected to replace oil-based mud as the drilling fluid of choice in major geographical areas.

Other fluid systems used in the oilfield industry are completion and workover fluids. By definition a completion or workover fluid is a fluid that is placed against the producing formation while conducting such operations as well killing, cleaning out, drilling in, plugging back, controlling sand, or perforating. Basic fluid functions are to facilitate movement of treating

fluids to a particular point downhole, to remove solids from the well, and to control formation pressures.

Required fluid properties vary depending on the operation, but
5 the possibility of formation damage is always an important concern. In recent years many new fluid systems have appeared, most due to the recognition of the high risk of reducing the productivity, or completely plugging certain sections of the producing zone, through contact with a foreign fluid.

10 A wellbore fluid typically contains a number of additives. Those additives impart desired properties to the fluid, such as viscosity or density. One class of additives is used as fluid loss agents to prevent the drilling fluid from entering into
15 porous formations.

The basic mechanism of fluid loss control is generally the formation of a filtercake at the interface of the porous or permeable formation layers. As part of the drilling fluid is
20 forced into the formation by the higher pressure within the wellbore, larger particles and additives are left behind and accumulate at the face of the formation. The filtercake thus formed can be regarded as a membrane that protects the formation from further invasion of wellbore fluids. Fluid-loss control
25 agents are selected in view of their quality to form a competent filtercake.

High molecular weight, oil soluble additives have been widely used as diverting agents and in water based drilling and
30 completion fluids. The additives help build an effective filtercake at the formation face and minimize damage. Under flowback conditions, the reservoir hydrocarbons readily dissolve the additive effectively creating holes in the filtercake and aiding formation cleanup. Having a hydrocarbon induced breakdown
35 of the filtercake avoids chemical intervention (clean-up) and

hence can result in a very cost-effective method of drilling wells for hydrocarbon production.

Many different oil soluble additives can be used to control fluid loss. In the application to drilling fluids, high molecular weight thermoplastic hydrocarbon resins are commonly used. United States Patent Nos 3,891,566 and 3,827,498 describes for example a mixture of two oil soluble resins one being friable and the other pliable as fluid loss control agents and as diverting agents. The resin must be used where oil exists and therefore it cannot be used in dry gas wells or in wells with temperature above its softening point. Its high molecular weight and impurities can make it only partially soluble in hydrocarbons causing the residues to damage or block the formation.

It is therefore an object of the present invention to provide a novel class of fluid loss additives that are able to form a competent filtercake while being easily removable from hydrocarbon bearing formations.

SUMMARY OF THE INVENTION

According to one aspect of the present invention, there is provided a low molecular weight, high melting point, crystalline, oil soluble additive for use in wellbore fluids that include drilling, completion, workover, fracturing, acidising, cementing fluids and the like.

The new additive is a wellbore-fluid additive which is preferably a ground crystalline material of melting point over 80°C, preferably over 100°C which is readily soluble in produced hydrocarbons such as crude oil and lighter condensates, and which exhibits a molecular weight of less than 1000, and preferably less than 650.

Its particle size can be adjusted to bridge efficiently across different pore size formations and control its solubility rate. A preferred particle size range is 10000 to 1 micron.

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Preferred examples of the low molecular weight crystalline additives are 1S-endo-Borneol, camphor or iodine. Other examples include beta carotene with a melting point of 184 degrees Celsius and a molecular weight of 537, lycopene (175; 537),
10 cholesterol (150; 387), lanosterol (139; 426), and agnosterol (165:424).

The invention reduces formation damage, flow initiation pressure, and increases the cleanup efficiency dependent on the
15 formation type. Compared to other additives, the low molecular weight crystalline additive can provide some important advantages. Firstly, the conventional high molecular weight resins, during the initial stages of dissolution in produced hydrocarbons, can be plasticized by the oil to a tacky material.
20 This tends to coalesce to a sticky mass and is very difficult to remove by dissolution. Secondly, the pressure required to start the backflow of oil through such filtercake can be high and therefore the resins have limited use in wells with low drawdown pressures. Thirdly, the level of impurities in the hydrocarbon
25 resin can limit its cleanup. By contrast, the low molecular weight crystalline solids of this invention dissolve smoothly and quickly to give low viscosity solutions.

In a variant of the invention, it is envisaged to reduce the
30 environmental hazards and nuisance caused by some of the new crystalline solids compounds by an encapsulating treatment.

These and other features of the invention, preferred embodiments and variants thereof, possible applications and advantages will
35 become appreciated and understood by those skilled in the art from the following detailed description and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 shows the fluid loss behavior of a drilling fluid dependent on the additive particle size and sequential fluid.

MODE(S) FOR CARRYING OUT THE INVENTION

Using 1S-endo-Borneol ($C_{10}H_{18}O$) having a molecular weight of 154 and melting point of 210 °C (410 °F), it was first bottle tested for its solubility in water, kerosene and kerosene with 5% mesitylene (aromatics) at 25 °C. 2 g of the additive added to 50 ml of the test fluid was insoluble in water but dissolved completely, within 5 minutes of mixing in kerosene and kerosene with mesitylene. There was no evidence of any residues in both cases. The additive was insoluble in water at higher temperature of 80 °C.

Tests were then performed to demonstrate the ability of this additive to increase the permeability of a drilling fluid filtercake when contacted with kerosene. A 2.5 inch diameter High Pressure-High Temperature filtration cell was used for the tests. Sequential static filtration tests were performed on a filter paper (2 micron pores) at 100 psi pressure and 25 °C temperature using the polymer/carbonate drilling fluid containing 10 ppb of the crystalline additive followed with kerosene. The composition of the drilling fluid is given in Table 1.

Table 1: Composition of a polymer/carbonate drilling fluid.

lb/bbl $g l^{-1}$

CaCl₂

	(74g in 835 ml of H ₂ O)	346	986
	Antifoam	0.2	0.6
5	Starch	6.0	17.1
	Scleroglucan	1.5	4.3
	Biocide	0.1	0.3
10	Calcium carbonate	45.0	128.3

The effect of varying the particle size of the additive (d_{50} of 400, 200, and 60 microns) was investigated. Care was taken not to disturb the filtercake when emptying the residual mud from the cell and introducing kerosene.

FIG. 1 shows the fluid loss behavior with elapsed time. After the mud cake build-up period of one hour, the kerosene dissolves the additive in the filtercake and increases its permeability to an extent that is particle size dependent. The strongest effect was observed with approximate particle size of 400 micron. But even 200 micron samples and 60 microns samples resulted in a much increased permeability. In the case of a fine grade the permeability increases by as much as 60 times whereas in the control test without the additive the rate increases by only 6 times. (DISCUSS FIGURE)

Filtercake examined at the end of the test showed pinholes distributed uniformly over the entire surface due to the dissolved additive whereas in the control test the pinholes were absent.

When water is flowed instead of kerosene through a drilling fluid filtercake containing 60-micron size additive there is no change in permeability, further demonstrating the efficient removal of the additive with kerosene.

To illustrate the ability of the present invention to reduce fluid loss, formation damage and initial backflow pressure,

tests were run in a High Pressure - High Temperature cell adapted for cores. The cores were 25.4 mm in diameter and 30 mm in length. Three outcrop cores (Ketton limestone, Clashach sandstone and Birchover sandstone) of widely different permeability and pore size were used. Their permeability was approximately 2400 mdarcy, 850 mdarcy and 10 mdarcy, respectively and median pore size was 60 μ m, 33 μ m and 2 μ m, respectively. The cores were first vacuum saturated in brine (45 gl⁻¹ NaCl and 5 gl⁻¹ CaCl₂) and then flushed with kerosene to residual water saturation. The initial permeability to kerosene was determined from the measured steady state pressure drop across the rock corresponding to the imposed range of constant flowrates (10, 8, 6, 4, and 2 ml min⁻¹). The flowrates used for Birchover was 5 times lower.

Static filtration tests were conducted for 4 hours at 300 psi differential pressure and 25 °C temperature using polymer/calcium carbonate drilling fluid containing 10 ppb of 60 micron additive (in the opposite direction to the kerosene flood). After filtration the cell was depressurised and a backflow of kerosene was imposed at 1 ml min⁻¹ to measure the peak (FIP or flow initiation pressure) and steady state flow pressure. The peak pressure correlates with the rupture of the filtercake. The final permeability was measured using the same procedure as used for the initial permeability. The retained permeability was defined as the ratio of final to initial permeability in percentage.

As shown in Table 2, the additive gave a two-fold increase in the retained permeability and reduced the spurt loss, fluid loss and FIP in the case of large pore size Ketton. The spurt loss was higher compared with the other two rocks of smaller pore size resulting in an internal filter cake. The cleanup of this internal cake was promoted by the presence of the additive resulting in a higher retained permeability and lower FIP. In contrast, an external filter cake was mainly built on the smaller pore size rocks. With little or no internal cake, the

additive contributed little to the retained permeability. However, the external filtercake with the additive was made more easily permeable indicated by a lower FIP by as much as 2 times in the case of Birchover sandstone.

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TABLE 2

Rock type	Drilling Fluid + / - Additive	Fluid loss at 4 hr g	Initial and final permeability mdarcy	Spur t loss g	Retained Permeability %	FIP psi
Ketton	-	2.4	2619 / 767	0.63	29	5.5
"	-	2.4	4817 / 929	0.78	20	8.0
"	+	1.8	2114 / 1276	0.47	60	3.0
"	+	1.6	2411 / 1647	0.41	68	2.1
Clashach	-	1.4	999 / 572	0.15	77	5.2
"	+	1.2	705 / 540	0.11	77	5.0
Birchover	-	1.5	7.2 / 6.8	0.06	92	76
"	+	1.3	11.7 / 10.2	0.06	87	41

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For an encapsulating treatment Borneol particles can be ground to an average particle size of 60 microns. Then, the particles can be spray coated using Piccopale 85-55KX oil soluble resin. The resulting coating is nominally 0.1 microns thick. These particles are then added to a typical reservoir water based drilling fluid (composition same as other examples).

15

CLAIMS

1. A wellbore service fluid to be injected from a surface location through a well tubular into a subterranean formation, said fluid being water based and comprising a particulate additive having the properties of being crystalline, soluble in hydrocarbons and insoluble in an aqueous solution.
2. The wellbore fluid of claim 1, wherein the additives have a molecular weight of less than 1000.
3. The wellbore fluid of claim 1, wherein the additives have a molecular weight of less than 650.
4. The wellbore fluid of claim 1, wherein the additives are prior to use in said wellbore fluid encapsulated.
5. Method of treating a wellbore, including the steps injecting from the surface a water based wellbore fluid comprising a particulate additive having the properties of being crystalline, soluble in hydrocarbons and insoluble in an aqueous solution;
letting said additive accumulate at the face of a permeable formation;
letting hydrocarbons enter said wellbore through said formation thereby dissolving at least part of said accumulated additive.



Application No: GB 9907017.9
Claims searched: 1-5

Examiner: D.B. Pepper
Date of search: 7 June 1999

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.Q): E1F FGP, FJT, FPA, FPD

Int Cl (Ed.6): C09K; E21B

Other: Online: WPI, EPODOC, PAJ

Documents considered to be relevant:

Category	Identity of document and relevant passage	Relevant to claims
A	GB 2294485 A (Sofitech N.V.)	-

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.